Sandy Hill Bridge
(Fenimore Bridge)
Joins Route 27 and Bridge Street
spanning the Hudson River
Hudson Falls
Washington County
New York

HAER No. NY-185

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HISTORIC AMERICAN ENGINEERING RECORD

SANDY HILL BRIDGE (FENIMORE BRIDGE)
HAER NO. NY-185

Location: The Sandy Hill Bridge spans the Hudson River and joins Route 27 in Fenimore, in the Town of Moreau, Saratoga County, and Bridge Street in the Village of Hudson Falls, Town of Kingsbury, Washington County, New York. The bridge is 500 feet upstream from Baker's Falls.

UTM: N 4794600
E 614380
New York State Quad: Hudson Falls

Dates of Construction: May 4, 1906 - January 8, 1907, altered in 1973.

Present Owners: Saratoga and Washington Counties.

Present Use: Vehicular and Pedestrian Bridge.

Significance: From 1907 to 1908, the Sandy Hill Bridge was the longest multiple span, reinforced-concrete arch bridge in the world. Its design was also the first to employ the use of separately molded concrete blocks for decorative purposes on the exterior spandrel walls, arch rings, and piers. Considering the scope of building a bridge of this magnitude in the infancy of reinforced concrete construction, eight months construction time was in itself a significant achievement.

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Immediately west of Hudson Falls, New York, is a half- mile stretch of the Hudson River above Baker's Falls which has long been the chosen area for river crossings. The first structure to span this part of the Hudson River, a toll bridge described as a "partly covered structure of wood," was completed in 1813.[1] In 1835, a flood washed this bridge away but a year later work was begun at the same site on not a new toll bridge, but a railroad bridge. Before work on the bridge had progressed beyond the building of the piers, a financial "panic" of unknown origins occurred and operations were halted.[2] Construction never resumed, but the piers were left standing and can still be seen today. For 65 years after this incident, there was no other attempt to span the river at this point.

The middle of the nineteenth-century saw water-powered industries and water-dependent mills flourishing along the river's edge at Sandy Hill.[3] The eighty foot drop of Baker's Falls was an ideal source of water power for the paper mills, lumber mills, and the large iron works manufacturing machinery for use in paper production which located their operations here. In 1895, the Union Paper Bag Machine Company bought out the Howland Paper Company of Sandy Hill, starting what was to become an extensive complex of paper- related mills owned by the national company.[4] Four years later, the Union Paper Bag Machine Company reorganized as the Union Bag and Paper Company (UBPCo.). By 1910, the company owned and operated three paper mills, four ground-wood mills, one sulphite mill, and a bag factory in Hudson Falls.

At its own expense, the company erected in 1901 a temporary wooden bridge across the Hudson River to connect its property and mills situated on the east bank with a new sulphite plant the company had constructed on the west bank. This bridge took 28 days to build and consisted of a series of Waddell "A" trusses set on stone-filled timber-crib piers. Although UBPCo. had the temporary bridge built for its own transportational needs, use of it was also extended to the general public through the purchase and use of a company bridge pass.[5] In view of the fact that this was the only river crossing in the Sandy Hill vicinity at this time, public use of the bridge steadily increased, eventually making the company concerned about its liability. In December, 1905, UBPCo. petitioned the Board of Supervisors of Saratoga and Washington Counties to replace the temporary bridge with a "permanent structure." Increased use and deteriorating conditions were cited as the main reasons for their decision.[6]

Some additional proposals set-forth in the company's petition were as follows:

1) The company was willing to join with the counties of Saratoga and Washington in constructing the bridge;

2) The company was willing to undertake the supervision of the construction of the bridge upon plans jointly approved by all parties involved;

3) It was willing to grant to the towns of Kingsbury and Moreau a right of way from the termini of the bridge to the public highways laid out and existing in the respective towns;

4) It guaranteed that the planning, supervision, and construction of the bridge would not exceed the sum of $60,000, of which the company would contribute one-third of the total cost, or $20,000;

5) In consideration of the large contribution it was willing to make toward the bridge's construction, the company requested the exclusive right to build and operate a railroad track over the bridge for its own transportational needs.

During the first two weeks of January, 1906, the Board of Supervisors of both Saratoga and Washington Counties appointed committees to work on the issues of the new bridge. On January 16, the two committees met at the office of UBPCo. and formed a Joint Committee. The new committee then listened to the plans submitted by representatives of different bridge construction companies, including UBPCo, as to the various types of bridge designs that would be suitable and capable of spanning 980 feet of the Hudson River above Baker's Falls. At the end of the meeting, a resolution was adopted that a concrete bridge be erected and that it be constructed according to the plans submitted by UBPCo. if they met with the approval of the members at the next meeting.

The Joint Committee met again February 14, 1906, to review drawings of the bridge submitted by Mr. M. O. Kasson, UBPCo.'s resident engineer, head representative for the bridge project, and primary designer of the bridge. Mr. Kasson explained in a general way the proposed construction of the bridge, having not yet heard from the company's consulting engineer Professor William H. Burr of Columbia University who was in charge of the specifications.

Specifications arrived in time for a February 24 meeting, at which time additions and modifications were suggested by members of the committee. The meeting adjourned without adopting the specifications because

> "...it was the sense of the Committee that the additions and modifications which were suggested to the specifications as submitted should...be incorporated in the specifications for the full protection of the two counties, one of the demands insisted upon by the [Counties'] Committee being a ten-year guarantee of the bridge by the Union Bag and Paper Company without expense for repairs or otherwise to the counties."[7]

The proposed restrictions and amendments -- including the ten year guarantee for the bridge's materials, workmanship, and durability -- were adopted by UBPCo. four days later. All matters being settled to the satisfaction of the parties involved, an agreement was entered into between the company and the two counties on February 28, 1906, stating, in essence, that UBPCo. would construct the bridge at a cost not to exceed $60,000, with Saratoga County, Washington County, and UBPCo. each paying one-third of the cost and UBPCo. paying anything in excess of $60,000. Orders to begin work on the new Sandy Hill bridge were received March 1, 1906 and construction started May 4, 1906.

The bridge, as planned and built, is a reinforced concrete structure consisting of fifteen equal arch spans, each measuring 60 feet in the clear between springing lines and having rises of 8 feet 6 inches. The low elevation of the banks and the extremely wide channel of the river at the building site required a bridge with a large number of spans of short length and a low deck height. The distance from the top of the intrados of the arches to the mean level of the river is only 21 feet 6 inches, while the distance between the river and the top of the deck is 24 feet. The piers have a thickness of 6 feet at the springing lines of the arches, making the distance between the faces of the abutments 984 feet. The total length of the bridge including the abutment walls measures 1,025 feet. The out-to-out width between the surfaces of the exterior spandrel walls is 35 feet 8 inches, while the distance between coping stones measures 32 feet. The latter measurement accommodates a roadway on the south side of the bridge and a sidewalk on the north. A single standard gauge railway track ran along the south side of the roadway until 1973 when the rails were removed as part of the bridge rehabilitation project.

Five internal-arch ribs constitute the primary supporting members for each of the fifteen spans. Two of the five ribs are considerably heavier than the remaining three, each being centered directly beneath each rail of the railway track situated on the south side of the bridge. The three lighter ribs support the remainder of the roadway and the sidewalk. All the ribs have steel reinforcements consisting of four angle irons latticed together on all sides by steel bars. This method of stiffening the arch ribs is known as the "Melan" system of reinforced concrete arch construction, named for Josef Melan, the Austrian engineer who invented the system.

After the first few piers were built at the beginning stages of the bridge's construction, it was found that the reinforcing for the arch ribs could not be received ready-fabricated and in the shape of the standard riveted members due to conditions of delivery and excessive cost. This situation necessitated immediate improvisation. The problem was solved by having the steel angles and lattice bars shipped directly to the construction site from the mills where a motor driven punching machine and a hand powered angle roller used for bending the steel angles were employed. Because this work was undertaken on site, each rib, when assembled, was bolted instead of being riveted together.

Associated with each of the arch ribs are internal spandrel walls which sit on top of the ribs and extend upwards to where they meet and support the concrete deck slabs. The walls extend for the full length of the bridge and, like the ribs, vary in thickness depending upon whether they lay beneath the railway tracks or not.

Flush with the bottom faces of the arch rings is soffit sheeting which is continuous and unbroken between the railway ribs and between the outside arch ribs and adjacent face walls. The remainder of the sheeting between the roadway-supporting ribs, however, is discontinuous. Here, soffit sections of 5 feet by 6 feet alternate with open spaces of approximately the same size between the arch ribs. The open and closed spaces are then staggered in the neighboring rings. For example, an open space in the ring between ribs No.2 and No.3 is opposite a sheeting section between ribs No. 3 and No.4, and then returns to an open section between ribs No.4 and No.5. Consulting Engineer Professor Burr stated in a paper presented to a meeting of the American Society of Civil

Engineers that the open spaces were left in the soffit sheeting in order to "lighten the structure as much as possible and to economize in material...."[8] However, a May 9, 1907, article in Engineering News stated that the main purpose for the openings was to allow the spaces enclosed by the road deck, spandrel walls, and soffit sheeting to be adequately ventilated by outside air.[9]

All of the cement used in the bridge was obtained from the plant of the Ironclad Portland Cement Company, located in Glens Falls, New York, about five miles from the Sandy Hill bridge.

According to the same Engineering News article cited above, some of the problems encountered in reinforced concrete construction during its first fifteen years of ambitious usage in the United States were "solved in a novel and effective manner" in the construction of the Sandy Hill bridge.[10] Apparently, the primary problems were considered to be securing an attractive face finish and economical form work in connection with rapid and inexpensive construction methods.

For this particular bridge, these problems were solved in the planning and erection stages by Mr. Kasson, but not without negative consequences, as time would ultimately prove. One of his earliest definite design proposals for the bridge -- an extremely novel one for this era of concrete construction -- was the use of separately molded concrete blocks for the entire face work. The forming of individual blocks was, as the Engineering News article states, largely responsible for the coincidentally low cost and aesthetically pleasing appearance of the bridge.

Local carpenters were hired to produce a large number of wooden molding forms which were designed in such a way that after they had been filled with concrete and allowed to set, the finished blocks would have channels or recesses along their beds and joints. Additionally, square, vertical holes were formed between the recesses on both sides of the blocks, the desired result being that when the blocks would be laid in place during construction, a honeycomb-effect of hollow spaces would be created. The setting of the blocks followed a specific procedure: Four or five courses would be laid at a time with jute being used to "caulk" the joints. Thick grout was then poured into the square openings in the blocks, with care being taken to fill as completely as possible the honeycomb void. After the grout had set, the jute was removed, the joints raked-out and then pointed. The entire process, from the design and form of the blocks to their being laid and grouted, was meant to produce a single, monolithic structure that would still possess the "highest obtainable degree of strength, solidity and water-tightness."[11]

The new idea of using concrete-block construction for the sole purposes of economy and adornment was met with justifiable criticism from other civil engineers. Henry H. Quimby, in a letter of response to Professor Burr's presentation to the American Society of Civil Engineers, accurately foresaw potential problems with this type of building method. While conceding that the Sandy Hill bridge was an "interesting illustration of the economic and aesthetic advantages of concrete as a material of construction," he concluded that

> "[t]he wisdom of the plan of [block] construction...will not be generally conceded. Shrinkage openings, as well as the almost inevitable voids that the grout will fail to fill because of entrapped air and other stoppages of flow, will be likely to collect water, which is a destructive agent in all masonry; and the claim made in the paper that the construction is monolithic is hardly warranted. The economy of the method is open to question, which...should be answerable by the record of cost on this work compared with the fairly definitely known cost of wooden forms. The other expressed purpose of the adoption of this system of construction -- to produce a satisfactory surface finish -- could have been easily accomplished in [standard] monolithic work by removing the face forms...and then scrubbing off the film from the surface, leaving the aggregate exposed to view."[12]

Mr. Quimby's assumption about water damage to the blocks was ultimately proved to be correct. It is safe to say that within twenty years after the bridge's completion, the outer sections of some of the blocks began to deteriorate at the base of their tapered backs due to freeze-thaw action, and eventually spalled. By 1945, when the first major inspection of the bridge was undertaken since its construction, the deteriorated condition of the blocks was considered to be in an advanced stage. The inspection, performed by consulting engineer Clarence W. Post of Albany, says that "many of these facing pieces have been forced out of place and are missing. Others are partially disintegrated exposing the pencil rod reinforcing within."[13] While the novel approach of using concrete blocks for exterior embellishment on the Sandy Hill bridge has proved to be a failure, the fact remains that this method of construction did not impede the short completion time and was not economically extravagant.

When the Sandy Hill bridge was opened for use in January, 1907, it was the longest multiple span, reinforced concrete arch bridge in the world. The reinforced concrete bridge that was to exceed in length the one at Sandy Hill was built over the Maumee River in Waterville, Ohio, in 1908. This bridge measured 1200 feet long and incorporated 12 arch-spans ranging in size from 75 to 90 feet.

The total cost of the bridge when completed exceeded the original estimate of $60,000 by about $17,000. This final cost included all finishing touches, such as lamp posts and the electric wires and poles needed for the electric railway. Roughly $5,000 was paid in overtime wages to the laborers, who ended up working many nights and Sundays in order to hasten the completion of the bridge because of the extremely dilapidated and dangerous condition of the temporary bridge upstream. Lastly, extra expense was incurred because of the need to keep working areas heated when concrete was being poured during freezing weather. All labor, excluding the carpenters, consisted of unskilled workers, and no skilled masons were employed at any time during the construction.

As stated earlier, the first inspection to be done on the Sandy Hill bridge since its completion was in 1945 under Mr. Post's authority. The inspection was necessitated because serious structural deformation and disintegration was becoming increasingly evident in some of the major structural members. In his report to the acting Washington County Superintendent, Mr. Post made it clear that his inspection "revealed no trace of any sort of expansion joint provision in the entire structure." Apparently not having read Professor Burr's report to the ASCE, Mr. Post's "careful detailed inspection" rediscovered aspects of the original design and construction which were poorly conceived and executed. In the ASCE report, Burr explained:

> "...over each pier and the crown of each arch the roadway and sidewalk plates are cut throughout the entire width between the copings of the exterior spandrel walls. The interior spandrel walls are also cut at the same points. These openings form expansion joints.... No other provision is made for expansion or contraction throughout the entire structure. The ribs, piers and abutments form a continuous reinforced concrete mass... without any provision for change of length, due to varying temperature or originating from other sources."[14]

Regardless, Mr. Post stated that if there were ever any joints between the deck slabs or in any of the individual spandrel walls they were either closed up tight or so compacted with dirt so as to be "completely obliterated." It is also important to note that a 1972 inspection report encountered the same circumstances, concluding that the "joints were poured tight during construction."[15]

The conclusion of the 1945 inspection report was that without the suitable provision for expansion and contraction in the total length of the structure, the cumulative effect of repeated alterations in the length of the structure as one unit had produced great compressive stresses, resulting in "severe local disintegration and fracture" of some of the structural elements.[16] The major defects were found in the three lighter arch ribs of the two end spans (those carrying the roadway and sidewalk). In view of the fact that these ribs are smaller than those under the railway track and that the arches are relatively thinner in section at their crowns than at their springing lines, it was believed that partial relief of the accumulated stresses was afforded in the crowns of these arches. The presumed result was that the mid-span of the arches were being forced upwards along with the spandrel walls sitting on them and the roadway plate, forming a noticeable hump on the riding surface of the bridge.

Recommendations for rehabilitative repairs were made in the 1945 inspection report and a year later notices for contractual bids were disseminated. The list of repairs included installation of expansion joints in the deck slabs and spandrel walls; removal of the concrete railings, lamp posts, and railway track; installation of new railings and lighting system; roadway repaving, drainage system repairs, and restoration of all deteriorated concrete. Evidence, however, reveals that none of the rehabilitative work spelled-out in the inspection report was undertaken at this time. In all likelihood, some unforeseen financial difficulties arose which prohibited the work from being executed.

In September, 1972, another detailed inspection report was prepared by Clough Associates, Consulting Engineers, of Albany.[17] Again, the reason for an in-depth inspection of the bridge was to determine the feasibility of repairing and rehabilitating it, in addition to considering "long range" replacement plans. The proposals for repairs contained within the report are the clues for what was not accomplished in 1946, namely removal of the concrete railings and railroad track, installation of new railings (or in this case, fence and guard rails), drainage system repairs, and restoration of deteriorated concrete (approximately 20% of the entire bridge exterior area). Other suggestions included the construction of new retaining walls and wingwalls behind both abutments, repair of the deck slab, laying of new sidewalk, and repaving the roadway. Of these items, only the removal of both the railings and the railway track, the installation of the barriers and pedestrian fence, the repointing of joints, and the laying of a new sidewalk and pavement were accomplished, with certainty, in 1973. All other items do not appear to have been initiated.

NOTES

1. Bicentennial Committee of the Town of Kingsbury and the Village of Hudson Falls, Warpaths, Wildcats, and Waterfalls: A View of Early Times in the Village of Sandy Hill and the Township of Kingsbury, (Glens Falls, N.Y.: Rist-Frost Associates, 1984), p. 39.

2. "Six Stone Piers at Hudson Falls Cause of Wonder," Glens Falls Post Star, February 4, 1936.

3. Certain legal records of 1800 and 1803 called the area around present-day Hudson Falls "Sandy Hill," and in 1810 it was enacted that part of the Town of Kingsbury be designated and known as the Village of Sandy Hill. In 1910 the name was changed to Hudson Falls. This information came from Warpaths, Wildcats, and Waterfalls.

4. James Cronkhite, Historian for the Village of Hudson Falls, said, in a telephone interview on August 26, 1987, that the Union Bag and Paper Company bought out the Howland Paper Company of Sandy Hill in 1895. According to David C. Smith, author of History of Papermaking in the United States, 1691-1969, (New York: Lockwood Publishing Co., 1970), p. 200, UBPCo. was not incorporated until 1899. I am assuming that UBPCo.'s parent firm, the Union Paper Bag Machine Company, bought Howland in 1895 before the reorganization and name change of 1899.

5. James Cronkhite, telephone interview on August 26, 1987.

6. Proceedings of the Board of Supervisors, Washington County, 1905, p. 44.

7. Proceedings of the Board of Supervisors, Washington County, 1906, p. 38.

8. William H. Burr, "The Reinforced Concrete Bridge Across the Hudson River at Sandy Hill, New York, (Paper No. 1055)," Transactions of American Society of Civil Engineers 59, (May, 1907): p. 198.

9. "The Sandy Hill Bridge over the Hudson River; A Long Reinforced-Concrete Arch Bridge with Block Facing." Engineering News 57 (May 9, 1907): p. 498.

10. Ibid, p. 497.

11. A.S.C.E. Transactions, Paper No. 1055, p. 199.

12. Ibid, p. 203.

13. Clarence W. Post, "Report of Inspection of Concrete-Steel Bridge Over the Hudson River, New York, for the Counties of Saratoga and Washington," (Albany, N.Y.: October 1945), p. 2.

14. A.S.C.E. Transactions, Paper No. 1055, p. 200.

15. Clough Associates, Consulting Engineers, "Report of the Fenimore Bridge over the Hudson River, Saratoga and Washington Counties, New York," (Albany, N.Y.: September 1972) p. 12.

16. "Report of Inspection of Concrete-Steel Bridge...," p. 12.

17. "Report on the Fenimore Bridge...," p. 19.